having low toxicity, which has an enough bonding strength while ensuring resistance to formation of whiskers, wettability of the solder and so on.

DISCLOSURE OF INVENTION

Thus, in order to achieve the objects of the invention, there is provided a bonded structure by a lead-free solder of an Sn-Ag-Bi alloy which is applied to an electrode through an Sn-Bi alloy layer.

In the invention bonded structure with utilization of the lead-free solder, the Sn-Bi alloy layer comprises 1 to 20 wt% Bi.

The invention bonded structure comprises a copper layer between the electrode and the Sn-Bi alloy layer.

In the invention bonded structure, the electrode is made of copper material.

In the invention bonded structure, the electrode is of a lead made of an Fe-Ni alloy or a copper alloy.

In the invention bonded structure, the lead-free Sn-Ag-Bi alloy solder comprises Sn as a primary component, 5 to 25 wt% Bi, 1.5 to 3 wt% Ag and up to 1 wt% Cu.

The invention is also directed to an electronic article which comprises a first electrode formed on an electronic device and a second electrode formed on a circuit board, the both types of electrodes

being bonded with each other by a solder, wherein an Sn-Bi alloy layer is formed on the first electrode and the solder is made of a lead-free Sn-Ag-Bi alloy.

In the invention electronic article, the Sn-Bi alloy layer comprises 1 to 20 wt% Bi.

The invention electronic article comprises a copper layer between the first electrode and the Sn-Bi alloy layer.

In the invention electronic article, the first electrode is made of copper material.

In the invention electronic article, the electrode is of a lead made of an Fe-Ni alloy or a copper alloy.

In the invention electronic article, the lead-free Sn-Ag-Bi alloy solder comprises Sn as a primary component, 5 to 25 wt% Bi, 1.5 to 3 wt% Ag and up to 1 wt% Cu.

The invention is also directed to a bonded structure by a lead-free solder, which comprises an electrode, wherein the lead-free solder is of an Sn-Ag-Bi alloy comprising Sn as a primary component, 5 to 25 wt% Bi, 1.5 to 3 wt% Ag and up to 1 wt% Cu, which is applied to the electrode.

As can be understood from the above, according to the present invention, it is possible to ensure a stable bonding interface having an enough bonding strength by applying the lead-free Sn-Ag-Bi alloy solder of low toxicity to an electrode such as a

lead frame. With utilization of the lead-free Sn-Ag-Bi alloy solder of low toxicity, it is also possible to ensure a bonding interface which is stable with respect to a change in process of time and which has a high enough strength to withstand stress generated in bonded portions by soldering due to a difference in thermal expansion coefficient between electric devices and a board, a work of dividing the board after soldering, warping of the board during the probing test, handling and so on. Further, with utilization of the lead-free Sn-Ag-Bi alloy solder of low toxicity, it is possible to ensure a bonding interface which has an enough strength and good resistance to occurrence of whiskers by forming sufficient fillets while keeping good wettability at a soldering temperature of, for example, 220-240°C.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 shows a cross-sectional view of a lead for a QFP-LSI according to the invention;

Fig. 2 shows a cross-sectional view of a lead for a TSOP according to the invention;

Fig. 3 schematically shows a testing way of evaluating solder-bonding strength;

Fig. 4 shows evaluation results of fillet strength with regard to various types of metallized leads according to the invention;

Fig. 5 shows evaluation results of wetting